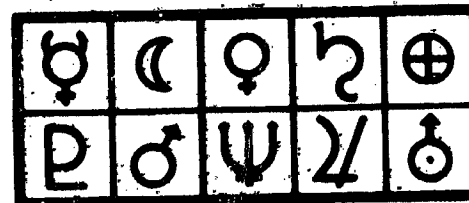


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CONTAMINATION CONTROL
TRAINING COURSE OUTLINE

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SANDIA LABORATORIES



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CONTAMINATION CONTROL TRAINING COURSE OUTLINE

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Sandia Laboratories
Albuquerque, New Mexico

March 1969

A basic course outline in the elements,
technology, and philosophy of contamination
control, including the application of principles
and the evaluation of effectiveness.

This work was performed under NASA Contract H-13245A.

PREFACE

This course outline considers the developing need for contamination control; the types, sources, and migration of contaminants; the methods for eliminating or controlling contaminants in liquids, gases, and on surfaces; and the means for evaluating the effectiveness of these controls. It also includes a treatment of the role of people in contamination control; how they both contribute and control contaminants.

The purpose of the outline is to provide the main points of discussion around which complete course material may be developed. The degree to which each part of the outline will be used will vary with the emphasis placed on each subject and the overall objective of the course.

The content of this course outline is designed for persons with little or no previous training in contamination control, but who anticipate entering some phase of the field and who have some appreciation for the technology involved.

CONTAMINATION CONTROL TRAINING COURSE OUTLINE

SCHEDULE OF TRAINING

<u>Lesson No.</u>	<u>Lesson Title</u>	<u>References</u>	<u>Time</u> *
1	Orientation and Introduction to the Course	Contamination Control Handbook, Preface; NASA SP-5045, Chapter 1	
2	Elements of Contamination Control	Contamination Control Handbook, Section 1; NASA SP-5045, Chapters 2 and 3	
3	Contaminant Types and Sources	Contamination Control Handbook, Section 1; NASA SP-5045, Chapter 2	
4	Migration and Retention Mechanisms of Contaminants	Contamination Control Handbook, Section 1	
5	Considerations for Contamination Control Requirements	Contamination Control Handbook, Section 2; NASA SP-5045, Chapters 3 and 4	
6	Control of Surface Contamination	Contamination Control Handbook, Section 3; NASA SP-5045, Chapter 6; Metals Handbook, 8th Edition, Volume 2, ASM; Contamination Analysis and Control, Dwyer, 1966, Chapters 8, 10, 11	
7	Control of Contaminants in Liquids and Gases	Contamination Control Handbook, Section 4; NASA SP-5045, Chapter 7; Contamination Analysis and Control, Dwyer, 1966, Chapters 3, 6, 10, 11; Matheson Gas Data Book, 1966	

*The time allotted for each lesson may be estimated for scheduling purposes by the company, agency, or institution using this course outline.

Lesson No.	Lesson Title	References	Time*
8	Control of Airborne Contaminants	Contamination Control Handbook Section 5; NASA SP-5045, Chapter 5, 10; Contamination Analysis and Control, Dwyer 1966, Chapter 9	
9	Control of Microbial Contamination	Contamination Control Handbook, Section 6; NASA SP-5045, Chapters 9, 10; NASA CR-61237, Biological Handbook for Engineers	
10	Radiant Energy Contamination	Contamination Control Handbook, Section 7; NASA SP-5045, Chapter "	
11	Clean Packaging	Contamination Control Handbook, Section 8; NASA SP-5045, Chapter 11	
12	Maintaining Product Cleanliness	Contamination Control Handbook, Section 9; NASA SP-5045, Chapter 11	
13	Integration of the Employee and a Clean Environment	Contamination Control Handbook, Section 10; NASA SP-5045, Chapter 12	
14	Measuring the Effectiveness of a Contamination Control Program		
15	Proficiency Test and Critique		

*The time allotted for each lesson may be estimated for scheduling purposes by the company, agency, or institution using this course outline.

LESSON OUTLINES

Lesson 1

Orientation and Introduction to the Course

Objective

To provide a general knowledge of the scope of the course and an introduction to the subject.

Discussion

1. Time and place of class meeting
2. General method of instructions to be used
3. Frequency and types of tests; grading system
4. Purpose of the course
5. Introduction to the Field of Contamination Control
 - a. History -- Prior to 1960; Housekeeping; Conventional rooms and glove boxes; Laminar airflow; Federal Standard 209; Scope of current applications
 - b. Needs and Interest -- Chemicals; Pharmaceuticals; Hospitals; Microelectronics; Component miniaturization; Television; Photographic films; Space vehicles
 - c. Defining the Field -- Scope; Disciplines; Training

Lesson 2

Elements of Contamination Control

Objective

To define and conceptually relate the elements of contamination control.

Discussion

1. Definitions: Contaminants; Environments; Effects; Controls; Monitoring; Contaminee
2. Relationship of the elements
 - a. Environments versus contaminants
 - b. Control versus contaminants and environments
 - c. Complexity of interrelations

Lesson 3

Contaminant Types and Sources

Objective

To provide a basic knowledge of the types of contaminants with which we are confronted, the sources from which they emanate, and the forms in which they are found.

Discussion

1. Types and forms of contaminants

- a. Particulate -- Dirt; Dust; Fibers; Corrosion; Body scale
- b. Gaseous -- Fumes; Vapors; Outgassing
- c. Liquid -- Condensates; Oils; Coolants; Skin oils
- d. Dissolved -- Oxygen; Chemicals
- e. Radiation -- Heat; Light; Sound; Motion; Radioactive
- f. Microbial -- Bacteria; Fungi; Rickettsiae

2. Sources and types of contaminants

- a. Atmosphere -- Gas; Airborne particulates
- b. Clothing -- Lint; Fibers
- c. Industrial Processes -- Heat; Films; Vapors; Particles
- d. People -- Bacteria; Oils; Hair; Skin
- e. Plants -- Fungi; Pollen
- f. Products -- Corrosion; Outgassing; Wear particles
- g. Radioactive Materials -- Particles; Rays
- h. Sun -- Rays; Light; Heat; Electromagnetic waves
- i. Transportation -- Fumes; Wear particles; Motion
- j. Construction -- Dust; Fumes

Lesson 4

Migration and Retention Mechanisms of Contaminants

Objective

To identify and define the mechanisms by which particles migrate to and are retained on surfaces.

Discussion

1. Migration mechanisms

- a. Fluids -- Suspended; Adsorbed; Dissolved
- b. Solids -- Entrapped; Adsorbed; Absorbed
- c. Waves -- Various wavelengths in the electromagnetic spectrum
- d. Contact -- Operators hands; Tools; Fixtures

2. Retention mechanisms

- a. Gravity -- Mass; Time; Surface angle
- b. Electrostatic Charge -- Attraction; Retention; Polar characteristics
- c. Molecular Attraction -- Adhesion; Adsorption
- d. Viscous Surface Coatings -- Oils; Grease; Compounds
- e. Physical Entrapment -- Porosity; Surface finish

Lesson 5

Considerations for Contamination Control Requirements

Objective

To provide a general knowledge of the factors to be considered in determining the need for individual control measures or a complete contamination control program.

Discussion

1. Product design considerations

- a. Cleanliness Requirements -- Functional needs
- b. Sensitive Areas -- Define the areas and their sensitivity to specific contaminants
- c. Materials -- Purity; Composition; Sloughing characteristics; Reaction to other materials
- d. Configuration -- Entrapment areas; Blind holes; Surface finishes; Dimensions and tolerances

2. Manufacturing, assembly, and testing

- a. Process Materials -- Purity; Recleaning; Replacement; Working conditions, Maintenance; Storage
- b. Environmental Control -- Temperature; Humidity; Airborne particulates
- c. Tools, Fixtures, and Equipment -- Condition; Surface finish; Contributing contamination; Proper use
- d. Cleanliness Verification -- Methods; Test equipment; Reliability of results

3. Systems requirements

- a. Use -- Particle sloughing; Wear; Safety; Filtering
- b. Exposure to Contaminants -- Type; Size; Quantity
- c. Maintenance -- Repair; Replacement; Introduction of Contaminants; Recertification

Lesson 6

Control of Surface Contamination

Objective

To introduce the various cleaning methods and to explore their capabilities, applications, and limitations.

Discussion

1. Cleaning agents

- a. Types -- Acid; Alkali, Solvent
- b. Characteristics -- pH; Surface tension; Boiling point; Flammability; Toxicity; Specific heat; Kauri-Butanol value; Advantages; Disadvantages
- c. Significance of Physical Properties
- d. Hazards and Cautions -- Flammability; Toxicity; Damage to materials

2. Cleaning methods

- a. Gross Cleaning -- Barrel; Abrasive blast; Mechanical; Washers; Agitation; Filtration
- b. Precision Cleaning -- Vapor degreasers; Ultrasonic cleaning
- c. Recontamination and Oxidation -- Solvent purity; Preservatives; Environmental control

3. Verifying surface cleanliness

- a. Types of Tests -- Direct and indirect. Quantitative and qualitative
- b. Specific Tests -- Visual; Water break; Contact angle; Radioactive tracer; Gravimetric; Solvent monitoring; Indium adhesion

Lesson 7

Control of Contaminants in Liquids and Gases

Objective

To acquaint the student with the types of contaminants normally found in gases and liquids, the various means of controlling these contaminants, and the methods used to verify purity.

Discussion

1. Information on gases

- a. Use -- Operating system gases; Process and system support gases
- b. Purity Levels and Grades
- c. Impurities -- Water; Oil; Other gases; Hydrocarbon; Particulates
- d. Sources of Contaminants -- Air leakage; All system components; Cleaning agents; System maintenance
- e. Contaminant Removal Methods -- Filters; Dryers; Molecular sieves
- f. Gas Analysis Methods -- Electromagnetic radiation; Reaction with other chemicals; Magnetic fields; Thermal or mechanical energy; Moisture monitors

2. Contaminants in liquids

- a. Types of Liquid Contaminants -- Nonvolatile residue; Other liquids; Adsorbed gases; Particulates; Microbial matter
- b. Contaminant Removal Methods -- Distillation; Sedimentation; Filtration; Centrifugation; Deionization
- c. Contaminant Detection Methods -- Filter and Microscope; Gravimetric method; Nephelometer; Spectrophotometry; Chromatography

Lesson 8

Control of Airborne Contaminants

Objective

To create an awareness of the problems associated with airborne contamination and to convey information on the means by which it may be controlled.

Discussion

1. Atmospheric air contaminants

- a. Natural
- b. Man-made
- c. Types -- Organic; Inorganic; Aerosols
- d. Control Devices -- Filters; Settling chambers; Scrubbers; Precipitators; Absorbers; Incineration

2. Air filters

- a. Types of Filters -- Activated charcoal; Industrial; Ventilation; Intermediate efficiency; High efficiency particulate air (HEPA)
- b. Filter Tests -- Weight; Discoloration; DOP

3. Nonlaminar airflow facilities

- a. Rooms -- Level of control; Garments; Housekeeping
- b. Work Stations -- Glove boxes
- c. Fume Hoods -- Balanced; Bypass; Conventional

4. Laminar airflow facilities

- a. Concept of Laminar Flow
- b. Characteristics -- Advantages; Disadvantages
- c. Rooms -- Vertical; Horizontal; Tunnels; Curtain units

- d. Benches -- Vertical; Horizontal; Balanced
 - e. Design and Operational Features -- Temperature; Humidity; Materials; Walls, ceiling, and floors; Plenums and ducting; Airlocks; Passthroughs
 - f. Equipment -- Chairs; Benches; Work surfaces
 - g. Garments -- Fabrics; Construction; Monitoring
5. Monitoring laminar airflow facilities
- a. Room -- Particle counters; Settling plates; Anemometer
 - b. Filters and Filter Bank -- Aerosol photometer; Manometer
 - c. Common HEPA Filter Leaks -- Media; Gasket; Frame; Support frame; Wall

Lesson 9

Control of Microbial Contamination

Objective

To provide a basic knowledge of microbial contamination and its control.

Discussion

1. Characteristics of microbial contamination

- a. Physical -- Size; Composition; Configuration; Color
- b. Metabolic and Nutritional Types -- Autotrophs; Heterotrophs
- c. Microbial Density -- Clean rooms; Body areas; Jet fuel; Soil; Water

2. Control of microbial contamination

- a. Deactivation -- Dry heat; Moist heat; Chemicals; Radiation
- b. Removal -- Filtration
- c. Isolation -- Biobarriers; Filtration; Pressure gradients

3. Monitoring microbial contamination

- a. Air and Gases -- Filter; Andersen and Reyniers samplers; All glass impinger
- b. Surfaces -- Rodac plates; Vacuum probe; Tape; Swab rinse; Immersion rinse
- c. Solids -- Diamond drill; Ball mill

Lesson 10

Radiant Energy Contamination

Objective

To briefly summarize the types of radiant energy contamination and the means by which they may be reduced or controlled.

Discussion

1. Types of radiation

- a. Electromagnetic -- Radio waves; Infrared; Ultraviolet; Light; X-ray; Gamma ray
- b. Mechanical -- Subsonic; Audible sound; Ultrasonic
- c. Particle -- Alpha; Beta; Neutron

2. Control methods

- a. Heat -- Insulation; Cooling; Reflection
- b. Sound -- Absorptive materials; Frequency filters
- c. Light -- Opaque materials
- d. Vibration -- Mounting; Dampeners; Absorptive materials
- e. Radioactivity -- Lead; Water; Most solid materials

3. Detecting radiant energy

- a. Light, X-Ray, Infrared -- Film; Photoelectric cell; Bolometer
- b. Particles -- Counters; Semiconductors; Dosimeter
- c. Sound and Vibration -- Microphone; Transducers; Velocity pickup;
Visual

Lesson 11

Clean Packaging

Objective

To emphasize the importance of maintaining the cleanliness of a clean item and to describe the methods and materials used for this purpose.

Discussion

1. Preparation for clean packaging
 - a. Cleanliness Levels -- Item; Packaging material; Equipment; Environment
 - b. Packaging Materials -- Selection; Verification
 - c. Facilities, Equipment, and Personnel -- Selection; Training; Requirements
2. Packaging materials
 - a. Types of Barrier Materials -- Polyethylene; Nylon; Aclar; Mylar; Aluminum Foil
 - b. Material Characteristics -- Strength; Sealability; Sloughing; Static charge; Resistance to oil and grease; Permeability; Cleanability; etc.
 - c. Accessory Materials -- Tape; Ties; Labels; Seals; Purging gas; Desiccant; Indicators
3. Closure and packaging methods
 - a. Intimate Cushioning -- Taping; Tying
 - b. Intimate Package -- Wrap; Bag; Disc or cover; Gasket and plate; Threaded plugs and caps; Rigid containers
 - c. Intermediate Package -- Environmental protection
 - d. Sealing -- Heat; Tape; Compression seals; Integrity seals
4. Verification of cleanliness
 - a. Packaging Materials -- Visual; Testing
 - b. Unpackaged Item -- Surface cleanliness

Lesson 12

Maintaining Product Cleanliness

Objective

To delineate some practical means of maintaining product cleanliness through handling, storage, transport, and use.

Discussion

1. Product handling

- a. Environments -- Containers; Barriers; Open storage in controlled environments
- b. Containers -- Cleanable; Nonshedding; Tight covers; Transparent; Lightweight

2. Tools and fixtures

- a. Features -- Cleanable; Smooth surfaces; Rounded edges; Self-lubricating
- b. Use -- Perforated racks; Recleaning

3. Storage and transportation

- a. Environmental Protection -- Heat; Humidity; Microbial growth
- b. Physical Protection -- Vibration; Shock; Pilferage; Theft

4. Maintenance and replacement

- a. Enclosed Uncontrolled Areas -- Cleaning; Particle producing activity; Overpressure; Garmenting
- b. Outdoor Areas -- Purging systems; Protective shelters; System overpressure; Clean tools; Clean packaged parts
- c. Tanks -- Purging; Ports; Cleaning; Personnel garmenting; Safety; Cleanliness verification

Lesson 13

Integration of the Employee and a Clean Environment

Objective

To emphasize the amount and types of contamination introduced by people into a clean environment and to provide direction as to how this type of contamination can be effectively controlled.

Discussion

1. Personnel contaminants
 - a. Types -- Scale; Flakes; Hair; Moisture; Clothing fibers; Cosmetics
2. Personal hygiene
 - a. Contaminating Condition -- Allergies; Nasal discharge; Epidermal shedding; Acid in body moisture; Itching; Sunburn; Chapping; Bandages
 - b. Recommended Personal Practices -- Bathe at night; Clean, unstarched clothes; Shave daily; Avoid rubbing exposed skin; Clean hands
3. Clean room training
 - a. General Topics -- Need for contamination control; Management recognition; Employee cooperation; Job knowledge; Garmenting; Contamination precautions; Rules of conduct
4. Special garmenting
 - a. Smocks and Suits -- Clean; Unstarched; Nonlinting; Pocketless
 - b. Gloves -- Approved fabric; Clean; Lint free
 - c. Caps -- Completely cover hair
 - d. Shoes -- Covers; Approved footwear
5. General clean room regulations
 - a. Eating and Smoking -- Prohibited
 - b. Personnel Movement -- Restricted
 - c. Maintenance -- Regular; As needed; Equipment
 - d. Writing Materials -- Approved paper and pens
 - e. Cosmetics -- Prohibited
 - f. Tools -- Use of; Cleanliness; Maintenance
 - g. Equipment -- Cleaned; Contained
 - h. Access -- Restricted

Lesson 14

Measuring the Effectiveness of a Contamination Control Program

Objective

To define methods that may be used to evaluate the effectiveness of a contamination control program.

Discussion

1. Applied controls versus cleanliness levels
 - a. Cleanliness Level Attained -- Unsatisfactory; Satisfactory; Excessive
2. Improved quality and reliability
 - a. Reject Rate
 - b. Rework
 - c. Functional Failures
3. Cost Analysis
 - a. Cost Versus Production Rate
 - b. Cost Versus Production Yield
 - c. Cost Versus Mission Objective

Lesson 15

Proficiency Test and Critique

Objective

To evaluate the students ability to assimilate and retain the information presented and to discover means of improving future courses on this subject.

Administration of the Test

Discussion

Informal class critique of the course.